METHOD FOR PRODUCING EXTERIOR COMPONENT OF ASSEMBLED CAMSHAFT

TECHNICAL FIELD

The invention relates to a method for producing an exterior component of an assembled camshaft used for a reciprocating engine.

BACKGROUND ART

As a valve gear mechanism for a reciprocating engine, there is employed a type in which a rocker arm, a swing arm, or the like is arranged between a cam and an intake/exhaust valve, as well as a direct drive type in which a cam is placed on a upper part right on an intake/exhaust valve (a tappet) to accommodate higher rotation and higher power of an engine. In general, a single-piece product formed by means of cast forming, forge forming, or cut forming is employed as a camshaft on which cams are formed. However, employment of an assembled camshaft has been promoted, since the assembled camshaft can arbitrarily specify mechanical properties (rigidity, hardness, lubricity, and so on) by a cam lobe and a shaft and comparatively easily achieve improvement of productivity, reduction of cost, and so on. The assembled camshaft includes, for instance, a hollow shaft which is made of a steel pipe or the like, and exterior components such as cam pieces, a nosepiece, and so on. The hollow shaft is fixed to the exterior components by means of weld bonding, press-fit fixation, tube expansion fixation, or the like.

The exterior components of the assembled camshaft are produced by means of various kinds of production methods. The following methods are publicly known. For instance, as a method for producing a cam piece mainly by means of a machining process, the following methods are proposed. In a method, a cutting process and a grinding process are applied to a peripheral surface of a hollow bar material to produce a cam piece

material with a predetermined cam profile. Then, the cam piece material is cut at a predetermined width to obtain a cam piece (a round-sliced cam) (Refer to Patent Document 1). In another method, a cutting process and a grinding process are applied to a peripheral surface of a solid bar material to produce a cam piece material with a predetermined cam profile. Then, a surface hardening process is applied to the cam piece material. After that, the cam piece material is cut at a predetermined width. And a shaft hole is made in the cam piece material which is then processed in order that a cam piece is obtained (Refer to Patent Document 2). Moreover, as a production method mainly by means of a plastic process, the following method is proposed. In the method, a material is settled in a thickness direction of a cam piece and a contour shape is forge-formed so that an intermediate workpiece is obtained. After that, a shaft hole is punched out at a center of the intermediate workpiece, and an inner peripheral surface of the shaft hole is finished (Refer to Patent Document 3). Moreover, the following method is proposed as a production method mainly by means of a casting process. In the method, a material of particle dispersed aluminum alloy is die-cast to form a cam piece with a shaft hole (a fit hole). Then, the shaft hole is machine-processed (Refer to Patent Document 4).

Patent Document 1: JP S52-41404 U (Paragraphs 0015-0022 and FIGs. 1 and 6)

Patent Document 2: JP H03-15609 A (Embodiment and Fig. 1)

Patent Document 3: JP 2003-285138 A (Paragraphs 0042-0046 and FIG. 1)

Patent Document 4: JP H09-256819 A (Paragraphs 0008 and 0009, and FIG. 1)

The production methods described in Patent Documents 1 and 2 are methods by which a hollow or solid bar material is machine-processed to form a cam piece. Therefore, there is a problem that an apparatus to form a cam profile (such as an NC copy lathe) and a cutting apparatus which cuts off a cam piece from a cam piece material are required. In addition, there is also a problem that more time and processes are required for production. Moreover, the production methods described in Patent Documents 3 and

4 are methods by which a cam piece is obtained by means of forge forming and cast forming. However, in the methods, the number of cam pieces obtained at a time through a forging process or a casting process cannot be large since cavity layout and so on in a metal mold is limited. Therefore, there is a problem that it is difficult to improve productivity.

DISCLOSURE OF THE INVENTION

In view of such a technical background, there is provided the present invention.

In one aspect of the present invention, there is provided a method for producing an exterior component of an assembled camshaft, including a casting step for casting a coupling of exterior components which has a shaft fit hole, in which plural exterior component original shapes between which vulnerable portions are inserted are coupled, and a dividing step for breaking the coupling of exterior components at one of the vulnerable portions to obtain the exterior component.

According to the production method, it is possible to obtain the coupling of exterior components which has a lot of exterior component original shapes and vulnerable portions, through a one-time casting process. Then, the vulnerable portions of the coupling of exterior components are hit and broken with an air hammer or manually. Therefore, it is possible to produce a lot of the exterior components in a short time.

In the production method, for instance, a bush which forms cam piece original shapes and notches and a sand core which forms a shaft hole are set in a metal mold. After that, molten metal such as cast steel is poured into the metal mold through a sprue. The thus obtained coupling of exterior components is set to a jig. Then, the notch is hit and broken with a tool which has a sharp tip of a blade so that the exterior component is obtained.

Moreover, in the method for producing the exterior component of the assembled

camshaft, the casting step may include a step for chilling the coupling of exterior components. As a result, the exterior component becomes harder. At the same time, it becomes easier to break the vulnerable portion of the coupling of exterior components. In the chilling step, for instance, a chiller made of copper alloy or the like is employed as a bush so as to quench the molten metal and chill the coupling of exterior components.

Various aspects and effects and other effects and more features of the present invention will be more apparent by detailed, illustrative and non-circumscribed description, which will be later described referring to accompanying drawings, of embodiments according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing an assembled camshaft according to an embodiment.

FIG. 2 is a cross-sectional view of an essential part of the assembled camshaft according to the embodiment.

FIG. 3 is a longitudinal sectional view showing a metal mold.

FIG. 4 is a longitudinal sectional view showing an essential part of the metal mold.

FIG. 5 is a perspective view showing a part of a chiller.

FIG. 6 is an explanatory diagram showing a step for casting a coupling of cam pieces.

FIG. 7 is an explanatory diagram showing that heat is removed from the coupling of cam pieces by the chillers.

FIG. 8 is a perspective view showing the coupling of cam pieces.

FIG. 9 is an explanatory diagram showing a breaking step of the coupling of cam pieces.

FIG. 10 is a perspective view of a cam piece.

FIG. 11 is an explanatory diagram showing an assembling step of the camshaft.

BEST MODE FOR CARRYING OUT THE INVENTION

Here will be described in detail an embodiment in a case where the present invention is applied to production of a cam piece of an assembled camshaft, referring to drawings, below. In the following description, "an assembled camshaft" is merely referred to as a camshaft.

A camshaft 100 shown in FIGs. 1 and 2 is a camshaft which drives an intake valve of a four-cycle DOHC four-cylinder engine. Cam pieces 9 and end pieces 102 are fixed to a hollow shaft 101 in order that the camshaft is produced. The hollow shaft 101 is a machining-processed product made of a cold drawn steel tube (for instance, a machine structure carbon steel tube STKM17C or the like). A peripheral surface of the hollow shaft is finish-grinded with reference to centers of both ends. Moreover, the cam piece 9 and the end piece 102 are cast products made of cast steel (for instance, low-alloy cast steel SCNCrM2) and are press-fit (or brazed) to the hollow shaft 101 so as to fit and fixed on the hollow shaft 101.

Next, there will be described an apparatus for producing the cam piece 9 according to the embodiment and process steps for producing the cam piece 9 and the camshaft 100 referring to FIGs. 3-11. In FIG. 3, main components of the casting apparatus 1 are a two-piece metal mold 2 and a core driver 3 which inserts a sand core 31 in the metal mold 2. The metal mold 2 includes an ingate 21 through which molten metal is injected, a sprue 22 which extends downward from the ingate 21, a runner 23 which horizontally introduces the molten metal from the sprue 22, a cavity 24 which extends upward from an end of the runner 23, and an opening 25 which is formed above the top end of the cavity 24.

As shown in FIG. 4, chiller holders 26 are formed in the metal mold 2. In addition,

a lot of chillers (chilling metals) 4 which form a cavity 24 are stacked and stored on the chiller holders 26. The chiller 4 is made of copper alloy which has excellent thermal conductivity. As shown in FIG. 5, an inner surface of the chiller has a cam piece original shape cast portion 41 and a notch cast portion 42. The notch cast portion 42 protrudes from an edge of one side of the chiller 4 (an edge on a left side in FIG. 5) toward inside of the cavity 24 around a perimeter.

As shown in FIG. 6(a), to produce the cam piece 9, a manufacturing worker inserts a sand core 31 inside the cavity 24 of the clamped metal mold 2 using a core driver 3. After that, as shown in FIG. 6(b), the manufacturing worker pours molten metal 51 into the metal mold 2 through the ingate 21 using a ladle 5. Accordingly, the molten metal 51 flows through the sprue 22 and the runner 23, and then into the cavity 24 and the opening 25.

As shown in FIG. 6(c), the molten metal 51 is injected into the metal mold 2 to form a cast material 7 which includes a coupling of cam pieces 6. In this case, in the embodiment, the cavity 24 is formed by the chillers 4. Therefore, as shown in FIG. 7, the chillers 4 rapidly remove heat from the coupling of cam pieces 6 immediately after the molten metal 51 is injected, so as to make the coupling of cam pieces 6 chilled (be a white cast iron). As a result, tensile strength and shear strength of the coupling of cam pieces 6 decreases while the coupling of cam pieces 6 becomes harder.

As shown in FIG. 6(c), when a predetermined time passes and the cast material 7 has completely solidified, the manufacturing worker causes the core driver 3 to release and move for removal (lift) the sand core 31. Next, the manufacturing worker opens the metal mold 2, takes out the cast material 7, and removes unnecessary parts (parts corresponding to the runner 23, the opening 25, and so on of the metal mold 2) and the sand core 31 so as to obtain the coupling of cam pieces 6. As shown in FIG. 8, cam piece original shapes (exterior component original shapes) 61 formed by cam piece original

shape cast portions 41 (See FIG. 4) and notches (vulnerable portions) 62 formed by notch cast portions 42 (See FIG. 4) are alternately formed in the coupling of cam pieces 6.

Next, as shown in FIG. 9, the manufacturing worker hits with a breaking tool 82 the notch 62 of the coupling of cam pieces 6 which is being held by a holder 81. Then, the coupling of cam pieces 6 with low tensile strength breaks at the notch 62 which is the vulnerable portion so that an individual cam piece 9 is obtained. As shown in FIG. 10, the cam piece 9 has a cam surface 91 formed by the cam piece original shape cast portion 41 (See FIG. 7), a shaft hole 92 formed by the sand core 31 (See FIG. 7), and a side surface 93 which is a fracture surface.

Next, as shown in FIG. 11, the manufacturing worker rough-processes the cam surface 91 and/or cut-processes the shaft hole 92 as needed, and then fits and press-fits the cam piece onto the hollow shaft 101. Next, the manufacturing worker attaches other exterior components such as a nosepiece and so on to the hollow shaft 101, and then finish-grinds the cam surface 91 to form a cam profile so as to obtain the camshaft 100 shown in FIG. 1. By the way, as shown in FIG. 1, in the camshaft 100, the side surface 93 of the cam piece 9 retains to be a fracture surface. However, only the cam surface 91 slides on a corresponding piece (a rocker arm or a tappet). In addition, the camshaft 100 which is assembled with an engine is not exposed. Therefore, there is no problem.

In the embodiment, the cam piece 9 and the camshaft 100 are produced through the process steps described above. Therefore, productivity has been greatly improved compared with conventional apparatuses while the cam piece has become harder.

Though the specific embodiment has been described above, embodiments of the invention are not limited to this embodiment. For instance, the embodiment is in a case where the invention is applied to a method for producing a cam piece. However, the invention is also obviously applicable to the other exterior components such as a journal, an end piece, and so on. Moreover, the materials of the cam piece and the hollow shaft,

as well as the specific structure of the metal mold, the material of the chiller, and so on are not limited to what are described in the embodiment, but are selectable or modifiable as needed in accordance with evaluation of cost or design, and so on.

INDUSTRIAL APPLICABILITY

The invention is applicable to production of an exterior component of an assembled camshaft used for a reciprocating engine, and contributes to improve productivity.